

## 4.2 Regulation Credits

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Each resource supplying pool-scheduled Regulation is credited at the higher of the five minute RMCCP and RMPCP with consideration of the resource's Regulation performance, and where applicable, the ~~mileage ratio~~ RMRTS or its five-minute Regulation offer price (plus real-time opportunity cost including shoulder hours' lost opportunity costs, for generating resources). A resource supplying self-scheduled Regulation is credited based on the five minute RMCCP and RMPCP with consideration of the resource's Regulation performance, and where applicable, the ~~mileage ratio~~ RMRTS. Regulation credits for joint-owned generators supplying Regulation are allocated to the owners based on their ownership shares.

Any resource with a five minute performance score below the applicable threshold for minimum performance as defined in Manual 11 Section 3.2.10 receives zero regulation credits for that five minute interval.

### PJM Actions

- From the Regulation log, PJM identifies each resource that supplied Regulation (both pool-scheduled and self-scheduled) with a five minute performance score greater than or equal to the applicable threshold for minimum performance as defined in Manual 11 Section 3.2.10.
- PJM calculates the five minute Regulation RMCCP Credit for each applicable regulating resource by multiplying each increment of such Regulation in megawatts during the five minute interval by the Regulation Market Capability Clearing Price (RMCCP), ~~the~~ applicable RMRTS, and the resource's actual performance score for that five minute interval. This result is then divided by 12 to determine the five minute interval RMCCP Credit.

$$\text{Regulation RMCCP Credit} = \text{Five minute integrated Regulation MW} \\ \times \text{Five minute Actual Performance Score} \times \text{RMRTS} \times \text{Five minute RMCCP} / 12$$

- PJM calculates the five minute Regulation RMPCP Credit for each applicable regulating resource by multiplying each increment of such Regulation in megawatts during the five minute interval by the Regulation Market Performance Clearing Price (RMPCP) for that hour, the applicable ~~mileage ratio~~ RMRTS, and the resource's actual performance score for that five minute interval. The result is then divided by 12 to determine the five minute interval RMPCP Credit

$$\text{Regulation RMPCP Credit} = \text{Five minute integrated Regulation MW} \\ \times \text{Five Minute Actual Performance Score} \times \text{Mileage Ratio} \times \text{RMRTS} \times \text{Five minute RMPCP} - / \\ 12$$

- PJM calculates the total Regulation Clearing Price Credit as the Regulation RMCCP Credit plus the Regulation RMPCP Credit for that five minute interval.

$$\text{Regulation Clearing Price Credit} = \text{Regulation RMCCP Credit} + \text{Regulation RMPCP Credit}$$

- The five minute lost opportunity costs calculated as part of the real-time pricing algorithm as adjusted by the applicable performance score and unit-specific ~~benefits factor~~ Regulation Rate of Technical Substitution (RRTS) are used in the settlement calculation for intra-hour lost opportunity costs.
- PJM calculates shoulder hours' lost opportunity costs incurred by each generator providing pool-scheduled Regulation for the three five minute ramp-in and ramp out intervals in the preceding and following hour. Note that the energy offer referred to below is the generator's incremental energy offer curve that is associated with the price-based or cost-based schedule used in the real-time dispatch of the unit.
- CT<sup>1</sup> and hydro generators are not eligible for shoulder hour lost opportunity costs.
- Generator eligibility for preceding shoulder hour lost opportunity costs is determined for each of the three ramp-in five minute intervals if all of the following conditions are met:
  - it is online in the ramp-in five minute interval;
  - the Regulation assignment starts at the top of the hour;
  - it is not regulating in all of the ramp-in five minute intervals;
  - the LMP Desired from the ramp-in five minute interval is not already within the regulation limits from the first five minute interval at the top of the regulation hour.
- Generator eligibility for following shoulder hour lost opportunity costs is determined for each of the three ramp-out five minute intervals if all of the following conditions are met:
  - it is online in the ramp-out five minute interval;
  - the Regulation assignment ends at the top of the following hour;
  - it is not regulating in all of the ramp-out five minute intervals;
  - the LMP Desired from the ramp-out five minute interval is not already within the regulation limits from the last five minute interval of the regulating hour.
- In each of the last three five minute intervals in the preceding hour of regulation, if a generator must reduce its output to provide regulation and foregoes revenues, its shoulder hour lost opportunity cost in that five minute interval equals the amount of its energy offer at the preceding five minute interval economically desired level in excess of its energy offer at its Regulation setpoint at the start of the regulation hour.
- In each of the last three five minute intervals in the preceding hour of regulation, if a generator must increase its output to provide regulation and incurs additional costs, its shoulder hour lost opportunity cost in that five minute interval equals the amount of its energy offer at its Regulation setpoint at the start of the regulating hour in excess of its energy offer at the preceding five minute interval economically desired level.
- In each of the first three five minute intervals of the following hour of regulation, if a generator increased its output to provide regulation and incurs additional costs, its

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<sup>1</sup> Unless otherwise specified, diesel unit types are treated as CTs in settlements based on their similar operating characteristics.

shoulder hour lost opportunity cost in that five minute interval equals the amount of its energy offer at its Regulation setpoint at the end of the regulating hour in excess of its energy offer at the following five minute interval economically desired level.

- In each the first three five minute intervals of the following hour of regulation, if a generator reduced its output to provide regulation and foregoes revenues, its shoulder hour lost opportunity cost in that five minute interval equals the amount of its energy offer at the following five minute interval economically desired level in excess of its energy offer at its Regulation setpoint at the end of the regulating hour.
- If the economically desired level, LMP desired MW, is less than or equal to the regulation low limit in the applicable five minute interval the unit regulated, the regulation set point equals the regulation low limit plus the regulation assigned MW in the applicable five minute interval the unit regulated. If the LMP desired MW is greater than or equal to the regulation high limit in the applicable five minute interval the unit regulated, the regulation set point equals the regulation high limit minus the regulation assigned MW in the applicable five minute interval the unit regulated. The regulation limits and assigned MW at the beginning of the regulating (first five minute interval) hour are used when calculating shoulder hour lost opportunity costs in the preceding shoulder hour while the regulation limits and assigned MW at the end of the regulating hour (last five minute interval) are used when calculating shoulder hour lost opportunity costs in the following shoulder hour.
- Since hydro units operate on a schedule and do not have an energy bid, lost opportunity costs for these units are calculated using the average of the real-time LMP at the hydro unit bus for the appropriate on peak (0700 - 2259) or off-peak (0000 – 0659, 2300 - 2359) period, excluding those hours during which all available units at the hydro plant were operating.
- During those five minute intervals when a hydro unit is in spill, the average of the real-time LMP value is set to zero such that the lost opportunity cost is equal to (i) the five minute regulation setpoint (biased to reflect the actual regulation signal and adjusted by the applicable five minute performance score and ~~benefits factor~~RRTS) multiplied by (ii) the full value of the five minute real-time LMP at the generator bus.
- If a hydro unit is committed day-ahead with MW greater than zero, the lost opportunity cost is equal to (i) the five minute regulation setpoint (biased to reflect the actual regulation signal and adjusted by the applicable five minute performance score and ~~benefits factor~~RRTS) multiplied by (ii) the difference between the five minute real-time LMP at the generator bus and the average real-time LMP (calculated as stated above). If this average real-time LMP value is higher than the five minute real-time LMP at the generator bus, the lost opportunity cost is zero.
- If a hydro unit is not committed day-ahead with MW greater than zero, the lost opportunity cost is equal to (i) the five minute regulation setpoint (biased to reflect the actual regulation signal and adjusted by the applicable five minute performance score and ~~benefits factor~~RRTS) multiplied by (ii) the difference between the average real-time LMP (calculated as stated above) minus the five minute real-time LMP at the generator bus. If

the actual five minute real-time LMP is higher than the average real-time LMP, the lost opportunity cost is zero.

- Additional details on hydro units in the Regulation Market can be found in Manual 11: Energy and Ancillary Services Market Operations.
- For each resource providing Regulation at the direction of PJM, the sum of its five minute Regulation offer price (and lost opportunity costs, including shoulder hours' lost opportunity costs, for generators) is compared to its five minute Regulation Clearing Price credits.
- If the resource's pool-scheduled Regulation offer price (plus lost opportunity costs, including shoulder hours' lost opportunity costs, for generators) is greater than its Regulation Clearing Price credit for that five minute interval, then the resource receives an additional credit equal to the amount that its Regulation offer price (plus lost opportunity costs, including shoulder hours' lost opportunity costs, for generators) is in excess of its Regulation Clearing Price credit:

*Lost Opportunity Cost Credit = (Regulation Offer + Lost Opportunity Cost, including Shoulder Hours' Lost Opportunity Cost, if applicable) / 12 – Regulation Clearing Price Credit, only if quantity is positive*

- Shoulder hour lost opportunity costs from the three five minute intervals of the ramp-in shoulder hour are applied to the first five minute interval of the regulating hour.
- Shoulder hour lost opportunity costs from the three five minute intervals of the ramp-out shoulder hour are applied to the last five minute interval of the regulating hour.
- PJM sums the Regulation credits (both Regulation Clearing Price credits and Lost Opportunity Cost credits) to determine the total hourly credit for each Regulation market participant, taking into account joint-ownership of regulating generators.